LETTERS TO THE EDITOR

ON THE NUCLEAR REACTION $Li^6(n, t)He^4$

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THE reaction $Li^6(n, t)He^4$ was investigated in Ref. 1 in the 1 – 14 Mev energy region on the basis of the two-particle model of the Li^6 nucleus, proposed in Ref. 2. This model assumes that the Li^6 nucleus can be considered as a system composed of a deuteron and an α-particle, the relative motion of which can be described by s-waves. It was assumed that the reaction $Li^6(n, t)He^4$ is the result of the direct interaction of the incident neutron with the deuteron of the Li^6 nucleus. In the matrix element the energy of the n-d interaction is replaced by the interaction energy of the deuteron with the α-particle. This interaction determines in addition the binding of the ground state of the nucleus $Li^6 = \alpha + d$, it being taken in the form of a potential well. On the basis of these assumptions an angular distribution was obtained in the Born approximation for the process, providing an explanation for the experimental fact that the cross section has a forward maximum.

In this work the question of the energy dependence of the total cross section of the process is investigated.

Taking into account the fact that on the basis of the assumptions in Ref. 1, the assumed analytic expression for the differential and total cross sections could not be obtained, we have changed some of the assumptions to obtain it.

First we take the interaction of the deuteron with the α-particle in the Li^6 nucleus to be not in the form of a potential well, but in the form of a potential oscillator with cut-off at a finite distance.[3] For the radial wave function corresponding to this potential, one can take to a satisfactory approximation, as has been shown in Ref. 3, the expression corresponding to a potential oscillator which extends to infinity. For an s-state this has the form

$$R(r) = \sqrt{2}\,(2\pi)^{-1/4}(r_0')^{-3/2}\exp\{-{}^1/_4\,(r/r_0')^2\},$$

where r_0' is the quantity connected with the nuclear radius and is introduced in the theory as a parameter.

Secondly, in the matrix element the interaction energy of the neutron with the deuteron is not replaced by the interaction energy between the deuteron and the α-particle; it is taken instead in an explicit way. Formally speaking, this interaction must consist of the two interactions between the incident neutron and each of the two nucleons that enter in the composition of the deuteron. However, instead of these two parts we take some average interaction, appearing as a function of the distance between the incident neutron and the center of the deuteron, and we assume that it has the form of a potential well of width 3×10^{-13} cm and of depth 7.81 Mev.[3]

For the wave function of the ground state of the deuteron we take the usual expression and for the triton the expression used in the work of Refs. 1 and 3. On the basis of these assumptions in the Born approximation we obtain as a result of the derivation the following expression for the total cross section of the process:

$$\sigma(E_n) = 2\pi\cdot 55.3\,(\alpha r_0')\,r_0'^2\,\Pi(E_n,\theta)\,e^{-2(a-b)}\,\frac{1-e^{-4b}}{2b}\sqrt{1+Q/E_n'},\quad a=(k_t r_0')^2+{}^4/_9\,(k_n r_0')^2,\quad b=4\,(k_t r_0')(k_n r_0')/3,$$

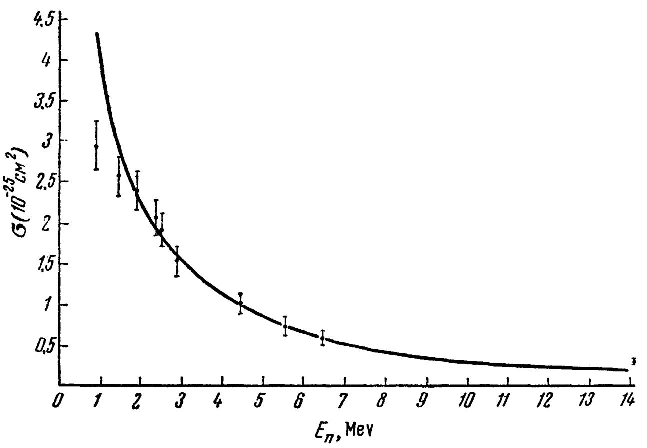
$$\Pi(E_n,\theta) = \Big\{\exp\Big[-\frac{(KS_0)^2}{4.5}\Big] - 0.388\,\frac{\sin KS_0}{KS_0} - 0.051\exp\Big[\frac{(KS_0)^2}{4.5}\Big]\Big[2\cos 2KS_0 - 0.734\exp\Big[\frac{(KS_0)^2}{4.5}\Big]$$
$$\times\Big(u_1\Big(\frac{KS_0}{\sqrt{4.5}}, 1.06\Big)\sin 3KS_0 + v_1\Big(\frac{KS_0}{\sqrt{4.5}}, 1.06\Big)\cos 3KS_0\Big)\Big]\Big\}^2, \tag{1}$$

where

$$u_1(x, y) + iv_1(x, y) = e^{-z^2}\int_0^z e^{t^2}dt, \quad z = x + iy,$$

is a tabulated function;[4] $\mathbf{q} = \mathbf{k}_t - 2\mathbf{k}_n/3$ and $\mathbf{K} = \mathbf{k}_t/3 - \mathbf{k}_n$, where $\mathbf{k}_t$ and $\mathbf{k}_n$ are the wave vectors of the corresponding particle in the center of mass system; Q = 4.56 Mev.

The energy dependence of the total cross section for $E \geq 1$ Mev, obtained from formula (1), is plotted in the figure for the parameter $r_0' = 1.5 \times 10^{-13}$ cm. The experimental results of Ref. 5 are indicated by the segments.



We see that in the energy region $E_n = 1 - 14$ Mev, the agreement of the theory with the experiment is satisfactory. Better results cannot be expected because of the very approximate character of the calculation. In the region of small energies the experimental cross section has a sharp maximum for $E_n = 0.25$ Mev, which is not shown on the figure and which our calculation does not give. This should have been expected, considering that an energy $E_n = 0.25$ Mev of the incident neutron corresponds to the formation of the Li^7 nucleus in one of its excited states (7.46 Mev), and consequently the process exhibits in this energy region a resonance which is not taken into account by us. The disagreement of the theory with the experiment in the region of small energies can also be ascribed to the fact that the use of the Born approximation is not permissible here.

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147

CONCERNING SUPERPOSITIONS WITH RESPECT TO THE INTERNAL PROPERTIES OF ELEMENTARY PARTICLES

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QUITE recently facts have been found that indicate the presence of an internal structure of elementary particles. One can try making the hypothesis that this internal structure and the internal motions associated with it determine the properties of elementary particles, in analogy with the situation that exists